

**An arrangement of truss cords**

The invention concerns an arrangement of the kind that is specified in the preamble of the patent claim 1.

**5 Generally known about the invention using today's technology**

The invention is a further development of the Swedish patent SE 502302 E04C 3/293 PCT SE 94/00700 An arrangement at a beam or a building element, particularly the truss web members which are illustrated in the figures 21 A-B and 22 A-D.

10 The invention according to this patent makes it possible to cast the cords in strengthening truss beams in a building element at the same time as one casts the element slab, to deal with the heavy handling needed by precast beams and to speed up the process.

15 This has been demonstrated to function well.

With the previous invention we have been successful in making building elements more quickly, and that are longer and stronger than usual without problems arising from deflection. The plumbing, electrical and other utilities can be installed inside 20 the building element quite rapidly, also. Circulating indoor hot air gives soft warm floors at very low installation costs as well.

**The problem**

25 On the other hand it has been impossible to manufacture truss webs according to the above-mentioned invention at moderate costs. With primitive manual bending arrangements the element has been made, in limited number, for laboratory tests and for the erection of some single family dwellings -- but as said 30 before, at all too high a cost.

The problem in the manufacturing is that today there are no automatic bending machines that bend the truss webs with sufficient precision and in one single bending cycle. Efforts have been made to bend the webs by using just two bending 35 cycles, but not even this has been able to be done with sufficient speed and precision. In addition, there is too much handling of the web parts. A normal single family dwelling contains over one thousand web parts, so each additional working moment results, overall, in a preposterous waste of time.

The goal is to create a truss with longitudinal rods that keep the web members fixed, and at the same time will function as reinforcement when being cast inside said chords and slab.

For practical reasons it is preferable to use a web member designed as in fig 22 C (in SE 502302 E04C 3/293 PCT SE 94/00700), with a base part on which the web member can rest during the joining. (In the present patent application this is illustrated in fig 5).

Please look at the two views fig 7 A and 7 B in the present patent application. (This is illustrated in fig 21 A and 21 B in the previous patent).

In fig 7 B the overlapping base shanks of the triangular web member must rest close to and touch each other, and must not be allowed to spread apart. They must also be situated at the same level so that the inclined web members inside the truss will not take up more height in the element slab. Otherwise, we would have to pour more concrete to make the element slab thicker to cover the reinforcement rods. Please observe that the web member cannot even be designed in mirror image. If it were to be so, the entire concrete slab must be made at least 10 mm thicker to obtain a sufficient concrete cover. This would cause a great number of inconveniences in unnecessary heaviness during transport, greater deflection, more material consumption, and so on.

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#### Two big obstacles

Modern automatic bending machines are not designed to make bends at angles larger than 180 degrees. The loop, in the present application marked (14), cannot for that reason be modelled in such a machine. Two steps in the production have therefore been necessary. First, a web rod is bent about 120 degrees in each end by using an automatic bending machine, to create a wide U. Next, a loop of about 220 degrees is bent in the centre of the web by using a bending-jig.

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Here the next problem arises.

It is impossible to shape the base shanks to be close to each other as described above. The problem is due, ironically, to technical drawing reasons, visualised in fig 22 C in the above-mentioned patent (in this application fig 5). As the web rods must meet in a cross at the loop, the base shanks land up at a level too far away from each other. If you force the shanks into

proper position these shanks must be locked, for instance, by a weld.

Or, you can force them to change places by wrapping them over each other. But now the flanks of the web rods are no longer

5 straight. These flanks form the uncovered part of the truss, tensioned and compressed. A curved rod has an injurious effect of the durability and strength of the construction, especially on the compressed truss rods.

10 Also another big problem occurs.

The web rods today consist exclusively of so-called ribbed reinforcement steel. Upon the lamination of these rods, there always occurs a longitudinal bead on the outside, which bead lands up in different axial positions inside the automatic 15 bending machine.

This bead makes the web rod turn in different directions when bent again for the second bending, so that the shanks that form the base part are no longer parallel. This is showed in fig 5.

20 Alternative manufacturing

There remains the alternative of manufacturing web parts in pre-cut length and then bend the loop at the first bending instead of the second bending. But this takes too long when being done manually and bending machines are too expensive.

25 This invention gives the solution to the above problems.

**The purpose of the invention and its most important characteristics**

The purpose of the invention is to obtain for the web rods as 30 many of the above-mentioned good qualities as possible, but without the above-mentioned disadvantages.

That is, to allow a sufficiently rational and economically feasible manufacturing process, with as high an automation level as possible to reduce the unit cost.

35 Concurrently, the purpose of the invention is to obtain satisfactory joining between a web rod and a cast chord or a slab. This will make the strengthening beam extraordinarily strong and light, with little material consumption and can now be manufactured at a much lower cost.

40 As a comparison, consider the most common truss beams with continuous plane and V-bent cast-in web rods. The main problem is the twists that occur in the cast-in bent part of the web

rod. This twisting occurs in each bending, being caused by the force directions of the web rods; the first force compressed and the other tensioned, which act to make the cord concrete to crack. Beams with plane bent webs simply don't function. The 5 chords will crack at minimum of load.

**The solution of the problem:**

There is, additionally, in spite of all variants described in 10 the afore-mentioned patent, especially in the figures 22 A-D, an essentially different way to bend webs that gives an almost equal effect.

The big difference in the new way (in this patent application) 15 is to bend the web rod so that no bending is greater than 180 degrees and, therefore, we are allowed to use standard automated bending machines. Furthermore, the geometry of this new way is such that we can still use hanging moulds, as in the afore-mentioned patent, with a straight division between the mould halves, in order to cast in the chords at the same working moment as the slab is cast.

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The problem has been solved by designing a web assembly according to patent claim 1 with the following characteristic qualifications.

- that the beam web assembly contains several truss web members 25 consisting of a rod bent to a triangular shape or a triangle like shape,
- that each truss web member has hook-like bends in both ends, the bends being mirror images of each other,
- that the middle of said web member is straight and forms the 30 base in said triangle shaped member,
- that said web member is bent, in the main symmetrical view, around the middle of said base part, the straight ends forming the side parts in said triangle shaped web member,
- that said end bends are oriented beside each other when seen 35 in the chord longitudinal direction and wrapped over adjacent to each other so that said straight ends of said web members intersect each other in one of said triangle corners, and together with said end bends form a loop so that one, with the chord, longitudinal reinforcement rod can be threaded inside said loops, where said end bends are somewhat or entirely transverse to the chord longitudinal direction and
- that said bends are cast in inside the chord,

Here is described the design of a web member by means of an imagined bending process. Fig 1 A - D.

- Start with a straight web rod then bend both the ends. If we 5 imagine the rod lying horizontally, the ends are bent downwards approximately 180 degrees. Then the web rod is bent again symmetrically around the straight part in the centre of the rod with two side parts mirrored upwards about 110 degrees until the ends of the web rod intersect each other. The web member now has 10 a triangular shape, where the upper corner forms when the ends overlap each other. The end bends are arranged so that the two bends together form a sufficiently sized loop, seen in the plane of the triangle, ready to be cast inside the chord.
- The loop has no ideal shape, as the ends have just been bent 180 15 degrees. The outermost parts of the ends are situated outside the ideal loop. Firmness tests in full scale have shown that the chord does not need to be made wider in order to cover these projecting ends. The main thing is that they land up well inside the hanging moulds that shapes the chord.
- 20 Further, the mould halves still can have a strait division in the joint between them, and can be joined tightly where the straight parts of the web ends cross each other.

#### In practice

- 25 In practice, when you use an automatic bending machine, the truss web is bent from a coiled rod. The web rod passes through a straightening apparatus then bent by four turns, counting first from the rod end we make the first end hook, after that the first base bending, then the second base bending and at last 30 the second end hook. After that the rod is cut and a truss web member is ready to be used.
- The bending process is now considerably much faster than before because we have access to this new bending method of truss web manufacturing.

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#### Further big advantages

Fig 3 A shows obviously that the two cast moulds halves used for shaping the chord (8) can still have a strait joint in the "x" which is formed by each web member's crossed shanks.

- 40 Further we can see in Fig 3 B that the truss web members have not any right- or left side, and can be assembled as they drop

after being manufactured. There is no trouble to get the end bends (2) and (2') close to each other.

The chord (8) must of course be made somewhat higher to maintain the concrete cover, but the material consumption is moderate when the chord is so thin.

#### A brief description of the drawings

Fig 1 A, B, C and D shows a way to bend truss web members (1,4), according to the invention, to describe the geometry.

Fig 2 shows in perspective truss web members (1,4), according to the invention, assembled into a truss, joined to longitudinal reinforcement rods (6,7,7'), ready to be cast inside a beam or a building element.

Fig 3 A and B shows, with two views, how a complete building element has been created with a slab (9) and a strengthening truss beam (15). The strengthening truss beam (15) consists of a chord (8) and a truss joined together by web members (1,4) and longitudinal reinforcement rods (6,7,7').

Fig 4 shows in three views, a complete building element ready for delivery.

Fig 5 shows in principle an example of a non-acceptable web member (13) according to the previous technique, with spreading, nonparallel ends (12).

Fig 6 shows, in perspective, an example of a desirable shape for a truss web assembly (13) according to the previous technique, with closely placed parallel end shanks (12).

Fig 7 A and B shows in principle, with two views, an example of a desirable shape of a truss web assembly (13) according to previous technique.

#### 30 Description of example of performance

Fig 1 A, B, C and D shows a way to bend truss web members (1,4), according to the invention, and to describe the geometry of the truss.

At the beginning, a straight web rod (Fig 1 A) is furnished with end bends (2,2'). The ends are bent downwards approximately 180 degrees (Fig 1 B). Then the web rod is bent again symmetrically around the straight part in the centre of the rod with two side parts mirrored upwards about 110 degrees (Fig 1 C) until the hook-like ends of the web rod intersect each other (Fig 1 D).

- The web member now has a triangular shape, where the upper corner forms when the ends (1,4) overlap each other. The end bends are arranged so that the two bends (2,2') together form a sufficiently sized loop, seen in the plane of the triangle,
- 5 ready to accommodate a longitudinal reinforcement rod (6) and ready to be cast inside the chord (8).
- Fig 2 shows in perspective truss web members (1,4), according to the invention, assembled into a truss, joined to longitudinal reinforcement rods (6,7,7'), ready to be cast inside a beam or a
- 10 building element.
- Fig 3 A and B shows, with two views, how a complete building element has been created with a slab (9) and a strengthening truss beam (15). The strengthening truss beam (15) consists of a chord (8) and a truss joined together by web members (1,4) and
- 15 longitudinal reinforcement rods (6,7,7').
- The bends (2,2') of the beam web members (1,4) are cast inside the chord together with a longitudinal reinforcement rod (6). The web member's (1,4) base parts (5) are together with two longitudinal reinforcement rods (7,7') cast inside the element
- 20 slab (9).
- Fig 4 shows in three views, a complete building element ready for delivery.
- Fig 5 shows in principle an example of a non-acceptable web member (13) according to the previous technique, with spreading, nonparallel ends (12).
- 25 Fig 6 shows, in perspective, an example of a desirable shape for a truss web assembly (13) according to the previous technique, with closely placed parallel end shanks (12). That is hard to obtain in practice.
- 30 Fig 7 A and B A and B shows in principle, with two views, an example of a desirable shape of a truss web assembly (13) according to previous technique. Please observe that the base shanks (12) lie in a horizontal level (a necessity) although not quite close to each other, which is hard to meet in practice.
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- The bends of the above truss web can of course also be made in other ways. Even if in essential parts only a few of the design options of the present invention have been shown on drawings and described above, it should be understood that the invention is
- 40 not restricted to these designs but are limited only to those indicated in the patent claims.